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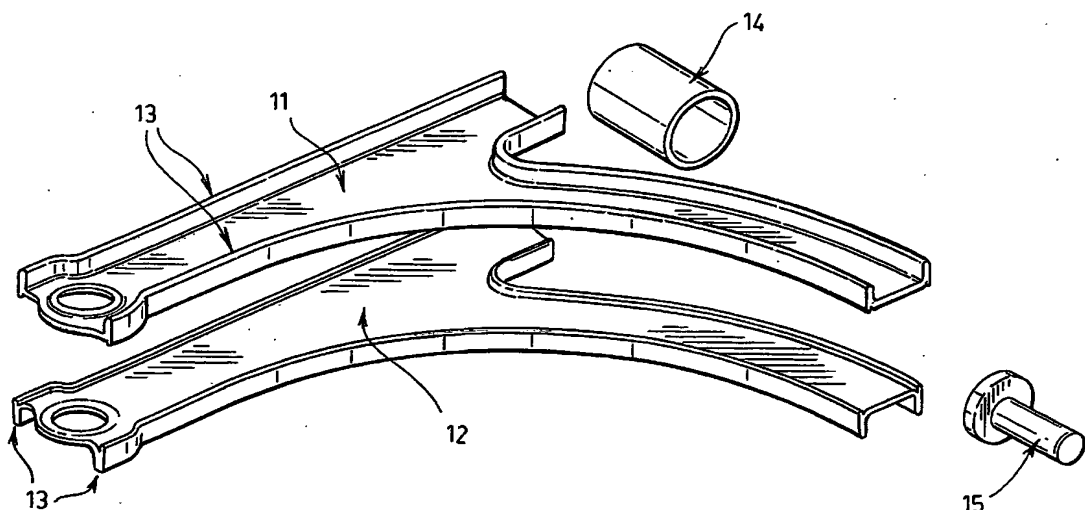
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(54) Title: **STRUCTURAL I-BEAM AUTOMOTIVE SUSPENSION ARM**



(57) Abstract: A vehicular suspension arm (10) comprises an upper sheet metal stamped component (11) with a first outer face and a first inner face (19), and a first central web portion (17) with two opposite sides and first upstanding flange portions (13) at opposite sides of the first web portion, a lower sheet metal stamped component (12) with a second outer face and a second inner face (19), and a second central web portion (17) with two opposite sides and a second upstanding flange portions (13) at the opposite sides of the second web portion, the first and second inner faces (19) adapted to contact each other along a substantial portion of the first and second web portions (17), the upper and lower stamped components (11, 12) adapted to be rigidly attached to each other to create a structural I-beam section, wherein the thickness of each upstanding flange portion (13) is at least equal to the combined thickness of the first and second web portions (17).



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STRUCTURAL I-BEAM AUTOMOTIVE SUSPENSION ARM

5 FIELD OF THE INVENTION

This invention applies to a manufacturing process for automotive suspension components, more particularly to those components requiring high stiffness to weight and strength to weight ratios. In particular, the invention applies to an automotive suspension arm.

DESCRIPTION OF THE PRIOR ART

Most modern road vehicles utilize some form of suspension system to isolate the passenger compartment from wheel disturbances caused by irregularities in the road surface. These suspension systems normally include some form of energy storage medium such as a spring, a device to control the spring's motion such as a damper, and a linkage arrangement to control the kinematics of the wheel movement. This combination of components is configured to allow the vehicle's wheels to move up and over road irregularities in a controlled manner. The most common form of linkage arrangement is a four-bar linkage configuration, constructed from the spindle assembly, the vehicle body, and two pivoting structural elements commonly referred to as control arms.

Figure 1 illustrates a common prior art four-bar link configuration. The control arms (1)(2) locate and guide the movement of the spindle assembly (3), relative to the vehicle body (4). The spindle assembly carries the wheel, tire, bearing assembly and brake assembly which are collectively referred to as the unsprung mass (5) of the vehicle. The unsprung mass also includes a portion of the control arm weight. Because there is significant energy

involved in moving the unsprung mass over road surface disturbances, it is preferable to reduce the combined weight of this subassembly as much as possible. Additionally, because the handling characteristics of the vehicle are directly dependent on the controlled movement of the unsprung components, it is imperative that the control arms have sufficient stiffness and strength to resist the substantial loadings that are imparted upon them.

It is therefore important that suspension control arms be strong and stiff to function well when loaded, as well as light in weight to reduce the unsprung mass. Reducing weight normally results in a reduction of both strength and stiffness. Great ingenuity is required to design parts with reduced weight but equivalent structural performance characteristics. The operational loads imparted on suspension control arms are discrete and well understood so that non-uniform structures can be developed to provide selective stiffness and strength in the directions and locations required by the application. Vehicle suspension control arms are generally configured in either an "A" or an "L" shape in plan view, depending on the configuration of the body mount to spindle relationship. In either case, the dominant induced loads are in the plane of the "A" or "L" formation and therefore require high in-plane stiffness. The most effective shapes for resisting these induced loads require a high concentration of material to be located around the edges of the "A" or "L" formation to maximize the in-plane second moment of area values. Figure 2 illustrates a common prior art "L" shaped suspension control arm (8) with a high concentration of material around the edges of the structure facilitated by a casting manufacturing process. This structure is consistent with common structural section practice where I-beams are considered the most effective method of carrying bending loads. An I-beam configuration concentrates material at the extremities of the section away from the centroid, or neutral-axis. Figure 2A is a cross-sectional view of a typical prior art I-beam, namely the cast "L" shaped suspension control arm of Figure 2. The opposing extremities of an I-beam are referred to as the flanges (6) while the

single centre component is referred to as the web (7). It is beneficial to have flanges which are at least as thick as the web to fully realize the structural advantages of an I-beam.

5 The requirement for optimized control arm structures to be non-uniform in shape has driven the use of a number of complex manufacturing processes. The most common manufacturing methods associated with vehicle control arm construction are casting, forging and the welding of press-formed metal stampings into subassemblies. Because of the complex shapes involved it is
10 nearly impossible to manufacture an optimized vehicle control arm from simple press formed metal stampings.

The majority of suspension control arms that utilize press formed metal stampings in their construction are configured as closed box sections. Figure
15 3 illustrates the section of a typical suspension control arm constructed from two U-shaped press-formed metal stampings. This type of structural section is far less efficient in resisting bending loads than an I-beam and requires a significant overlap of material to facilitate the required weld fillet joint. This material overlap is ultimately structurally redundant and results in a heavier
20 solution than alternative cast or forged configurations.

U.S. Patent No. 5,662,348 issued to Kusama et al discloses a suspension arm manufactured from press-formed parts. Kusama claims a wide range of different sectional configurations all aimed at stiffening a vehicle suspension
25 control arm in a manner that is compatible with the induced loads. However, Kusama does not teach a method for creating a true I-beam section using press-forming techniques.

The use of I-beam sections is known in suspension arm technology and
30 normally involves manufacturing using casting or forging techniques as illustrated in Figures 2 and 2A. However, it has also been common practice to

utilize two cup-shaped press formed stampings, arranged back-to-back and projection welded together to create an I-beam section with the required plan view shape. Although I-beam sections have been created by combining two relatively simple stampings in this way, the flanges have been half the thickness of the web, which has resulted in poor structural performance. Figure 4 illustrates a cross-sectional view of a typical prior art I-beam suspension control arm constructed from two cup-shaped press-formed stampings. It is important to note that the prior art manufacturing process dictates that the flanges are of a single material thickness while the web is of double material thickness. This is not an optimal structural configuration.

SUMMARY OF THE INVENTION

Accordingly, it would be advantageous to create a suspension control arm that could provide high inherent stiffness and strength while maintaining relatively low mass using a low cost manufacturing technique such as sheet metal press-forming. It has been proven that for large volume applications such as those dictated by the automotive industry, sheet metal press-forming is the most cost-effective method of manufacturing structural components. Almost every vehicle currently produced utilizes a body structure and selected subframes constructed almost entirely from either aluminum or steel stampings manufactured using press-forming techniques. The aim of the present invention, therefore, is to utilize metal press-forming in the manufacture of a vehicle suspension control arm.

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In an embodiment of the invention, a vehicle suspension control arm is constructed by welding two complex press-formed stampings together to form a highly efficient I-beam cross-section. Each stamping is configured with the correct plan view shape, namely an "A", "L", or other appropriate shape for the application, and is formed into a cup-shape section with the upstanding flanges fully returned back upon themselves to effectively double their

30

thickness. The two stampings are then placed together in a back-to-back arrangement and welded along the free, peripheral edges. A key aspect of the configuration is that the trim edges of the folded over upstanding flanges leave an adequate gap to facilitate a high quality, four material weld. In other words, the welds join both the two web portions and the two flange portions along each peripheral edge of the part. The final assembly possesses a favorable structural I-beam section since the flanges and web have essentially the same thickness.

Accordingly, a vehicular suspension arm comprises: an upper sheet metal stamped component with a first outer face and a first inner face, and comprising a first central web portion and first upstanding flange portions at opposite sides of said first web portion; a lower sheet metal stamped component with a second outer face and a second inner face, and comprising a second central web portion and second upstanding flange portions at opposite sides of said second web portion; said first and second inner faces adapted to contact each other along a substantial portion of said first and second web portions; said upper and lower stamped components adapted to be rigidly attached to each other to create a structural I-beam section, wherein the thickness of each upstanding flange portion is at least equal to the combined thickness of the first and second web portions.

In further aspects of the invention:

- a) the upper and lower stamped components are press-formed from sheet metal of uniform thickness, and each upstanding flange portion comprises a fully returned segment of said sheet metal, whereby the thickness of each upstanding flange portion is at least double the thickness of each web portion;
- b) the upper stamped component and lower stamped component are press-formed from sheet aluminum, sheet steel, or similar sheet metal materials;

- c) the upper stamped component and lower stamped component are rigidly attached to each other in a back-to-back configuration using welding, bolting, riveting, adhesive bonding, or similar fastening means;
- 5 d) the upper stamped component and lower stamped component are configured when placed into contact along said first and second inner faces to create a gap along a peripheral, joining edge suitable for facilitating a high quality welded joint which combines both butt and fillet configurations to join four
- 10 material surfaces of the upper and lower components, and said upper and lower components are rigidly attached to each other by means of said welded joint;
- e) the upper stamped component and lower stamped component are rigidly attached to each other along said first and second
- 15 inner faces in a back-to-back configuration using projection welding across the respective first and second web portions;
- f) the upper stamped component is configured with a first extruded opening at a predetermined point in the first web portion, and the lower stamped component is similarly
- 20 configured with a second extruded opening in the second web portion, so that the first and second extruded openings align when the upper and lower stamped components are rigidly attached to each other to create a suitable structure to accept a ball joint of a spindle assembly;
- 25 g) at least one discontinuity is introduced in the fully returned flanges to create a suitable structure to accept vehicle body attachment details.

30 **BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a perspective view of a common four bar link vehicle suspension system;

FIG. 2 is a perspective view of a typical cast prior art suspension control arm;

FIG 2A is a sectional view of the typical prior art suspension control arm of
5 Fig.2;

FIG. 3 is a sectional view of a typical stamped prior art suspension control arm;

FIG. 4 is a sectional view of a typical stamped, I-beam section prior art suspension control arm;

10 FIG. 5 is a perspective view of the inventive suspension control arm;

FIG. 6 is an exploded perspective view of the inventive suspension control arm;

FIG. 7 is a typical sectional view of the inventive suspension control arm;

FIG. 7A is an exploded typical sectional view of the inventive suspension
15 control arm;

FIG. 8 is a typical sectional view of a preferred embodiment of the inventive suspension control arm including details of the welded joint.

20 **DETAILED DESCRIPTION OF THE INVENTION**

Referring to Figures 5, 6, 7, 7A and 8, a vehicular suspension control arm (10) is substantially constructed from an upper stamped component (11) and a
25 lower stamped component (12). Both the upper and lower stamped components are manufactured by press-forming a flat sheet of steel, aluminum or other suitable metal or alloy into a required plan view shape which is dictated by the vehicle's suspension geometry requirements. Additionally, both the upper and lower stamped components are configured, during the
30 press-forming process, with a cup-shaped section containing upstanding flanges (13) in which the material is fully returned back upon itself to effectively double the section thickness in this area. These fully returned

flanges (13), of double material thickness run around the entire periphery of the stamped components with the exception of localized areas requiring special formations to facilitate the vehicle body attachments (14)(15) and the spindle attachment (20).

5

The final suspension control arm structure (10) is completed by rigidly attaching the upper stamped component (11) and lower stamped component (12) in a back-to-back configuration using bolting, welding, adhesive bonding, riveting or similar fastening means. A typical section that results from the back-to-back attachment of the two stamped components is illustrated in the cross-sectional view of Figure 7. In this manner, a highly effective I-beam section is created with the fully returned flange (13) thickness (T1) and web (17) thickness (T2) being identical and therefore structurally superior to the prior art section illustrated in Figure 4.

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In a preferred embodiment of the present invention, the fully returned flanges (13) of the upper stamped component (11) and lower stamped component (12) are configured with a trim edge (18) that is set at a predetermined distance (D1) from the interfacing surface (19) of the web (17). This distance (D1) then creates a gap (D2) between the trim edges of the upper stamped component (11) and the lower stamped component (12) suitable for facilitating a high quality, four material weld joint created by GMAW or similar welding means. On each edge of the assembled control arm, the opposing flanges and opposing webs are thus joined. Figure 8 illustrates a cross-section of the preferred embodiment suspension control arm showing how an extremely rigid contiguous I-beam section is created by utilizing a four material weld joint around the periphery of the structure. The resulting weld joint is unique in that it is configured as a combination of a perpendicular fillet joint and a butt joint due to the four different material surfaces that it has to join. This weld can be continuous or discrete.

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Referring to Figures 5 and 6, the suspension control arm (10) is configured with a flanged hole (20) suitable for accepting the ball joint of the spindle assembly (3). This flanged hole (20) is created by punching and press-forming an extruded hole into both the upper stamped component (11) and lower stamped component (12) such that the extrusion direction is generally the same as that of the upstanding flanges (13) and the holes are dimensionally located in both of the stamped components (11)(12) so that they accurately align when the components are rigidly attached. The suspension control arm (10) is also configured with at least one discontinuity in the upstanding flanges so that the vehicle body attachments (14)(15) can be facilitated. This discontinuity can be of complex shape adapted to accept a perpendicularly oriented, round bushing support (14) or a simple, straight cut-off adapted to accept an in-line pin (15).

Although, a preferred embodiment of the invention has been illustrated, it will be apparent to the skilled workman that variations or modifications of the illustrated structure may be made without departing from the spirit or scope of the invention.

CLAIMS

- 5 1. A vehicular suspension arm, comprising:
- an upper sheet metal stamped component with a first outer face and a first inner face, and comprising a first central web portion with two opposite sides and first upstanding flange portions at said opposite
10 sides of said first web portion;
- a lower sheet metal stamped component with a second outer face and a second inner face, and comprising a second central web portion with two opposite sides and second upstanding flange portions at said
15 opposite sides of said second web portion;
- said first and second inner faces adapted to contact each other along a substantial portion of said first and second web portions;
- 20 said upper and lower stamped components adapted to be rigidly attached to each other to create a structural I-beam section, wherein the thickness of each upstanding flange portion is at least equal to the combined thickness of the first and second web portions.
- 25 2. The vehicular suspension arm of Claim 1, wherein the upper and lower stamped components are press-formed from sheet metal of uniform thickness, and each upstanding flange portion comprises a fully returned segment of said sheet metal, whereby the thickness of each upstanding flange portion is at least double the thickness of each web
30 portion.

3. The vehicular suspension control arm of Claims 1 or 2, wherein the upper stamped component and lower stamped component are press-formed from sheet aluminum, sheet steel or similar sheet metal materials.
5
4. The vehicular suspension control arm of Claims 1, 2 or 3, wherein the upper stamped component and lower stamped component are rigidly attached to each other along said first and second inner faces in a back-to-back configuration using bolting, welding, bonding, riveting or
10 similar fastening means.
5. The vehicular suspension control arm of Claims 1, 2 or 3, wherein the upper stamped component and lower stamped component are configured when placed into contact along said first and second inner
15 faces to create a gap along a peripheral, joining edge suitable for facilitating a high quality welded joint which combines both butt and fillet configurations to join four material surfaces of the upper and lower components, and said upper and lower components are rigidly attached to each other by means of said welded joint.
20
6. The vehicular suspension control arm of Claims 1, 2 or 3, wherein the upper stamped component and lower stamped component are rigidly attached to each other along said first and second inner faces in a back-to-back configuration using projection welding across the respective
25 first and second web portions.
7. The vehicular suspension control arm of Claims 1, 2, 3, 4, 5 or 6, wherein the upper stamped component is configured with a first extruded opening at a predetermined point in the first web portion, and
30 the lower stamped component is similarly configured with a second extruded opening in the second web portion, so that the first and

second extruded openings align when the upper and lower stamped components are rigidly attached to each other to create a suitable structure to accept a ball joint of a spindle assembly.

- 5 8. The vehicular suspension control arm of Claims 2, 3, 4, 5, 6 or 7, wherein at least one discontinuity is introduced in the fully returned flanges to create a suitable structure to accept vehicle body attachment details.

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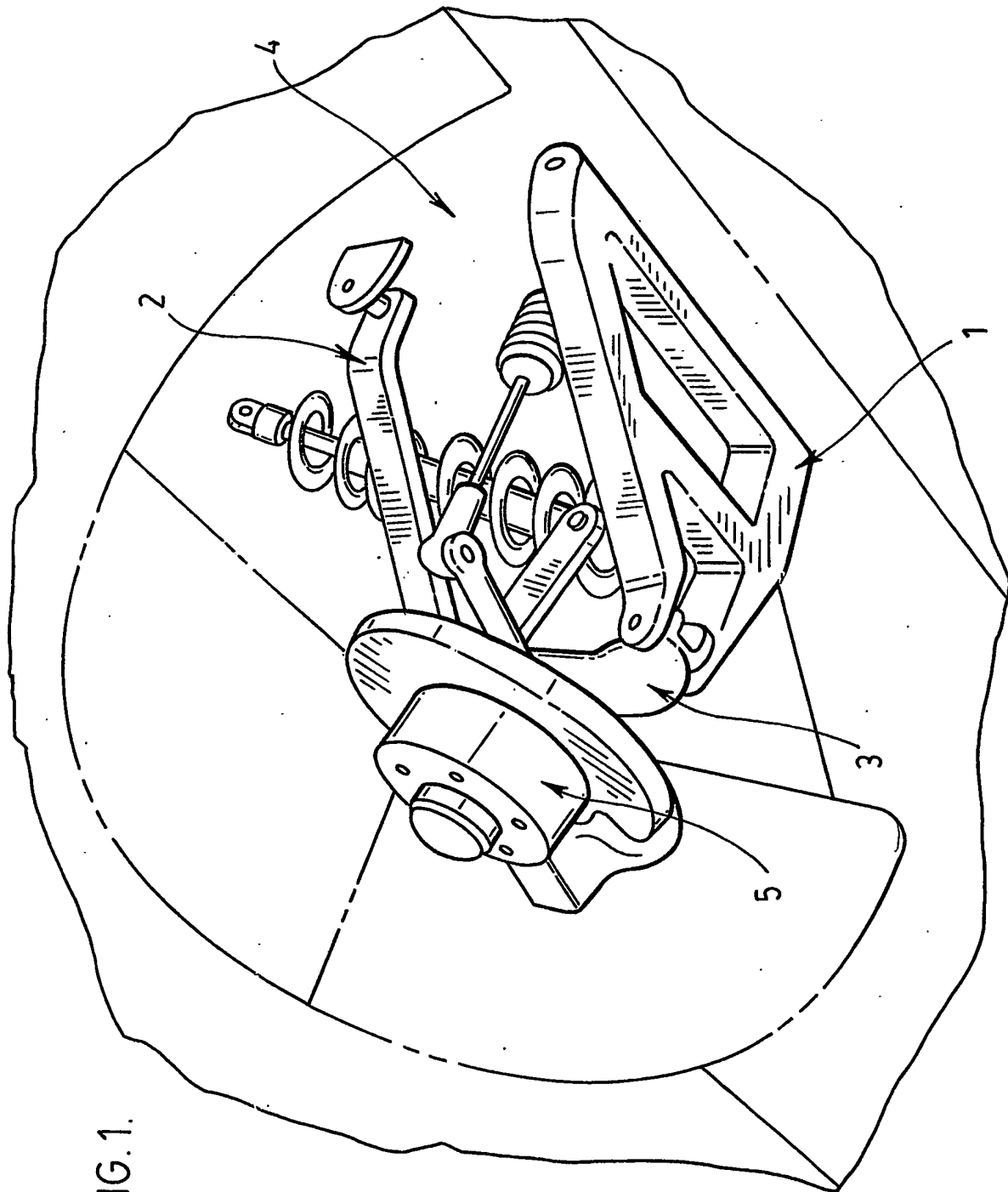


FIG. 1.

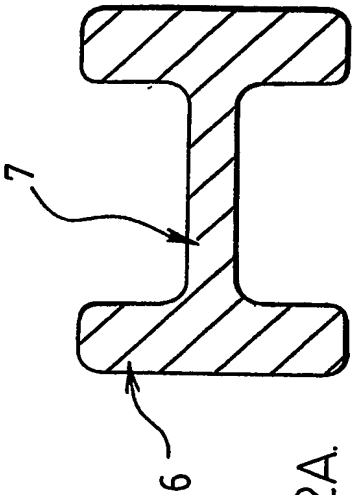
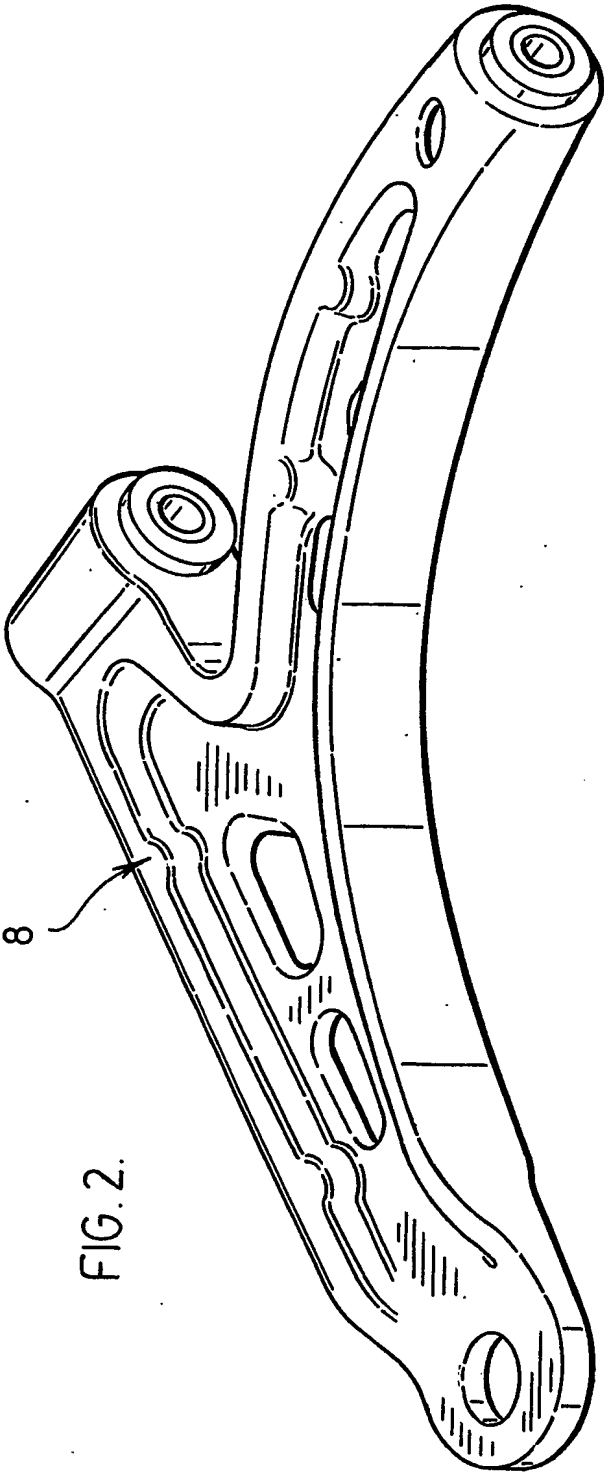


FIG. 2A.

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FIG. 3.

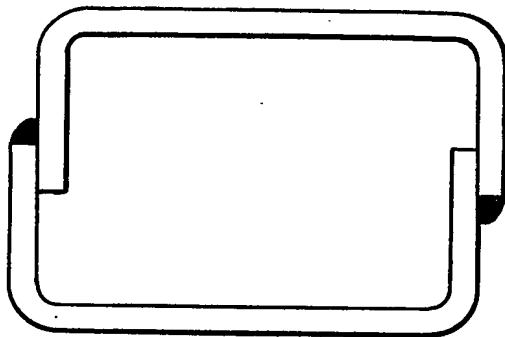


FIG. 4.

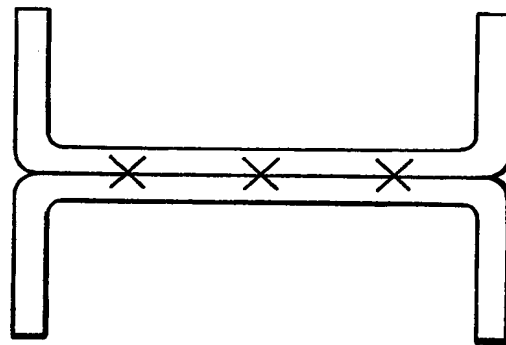
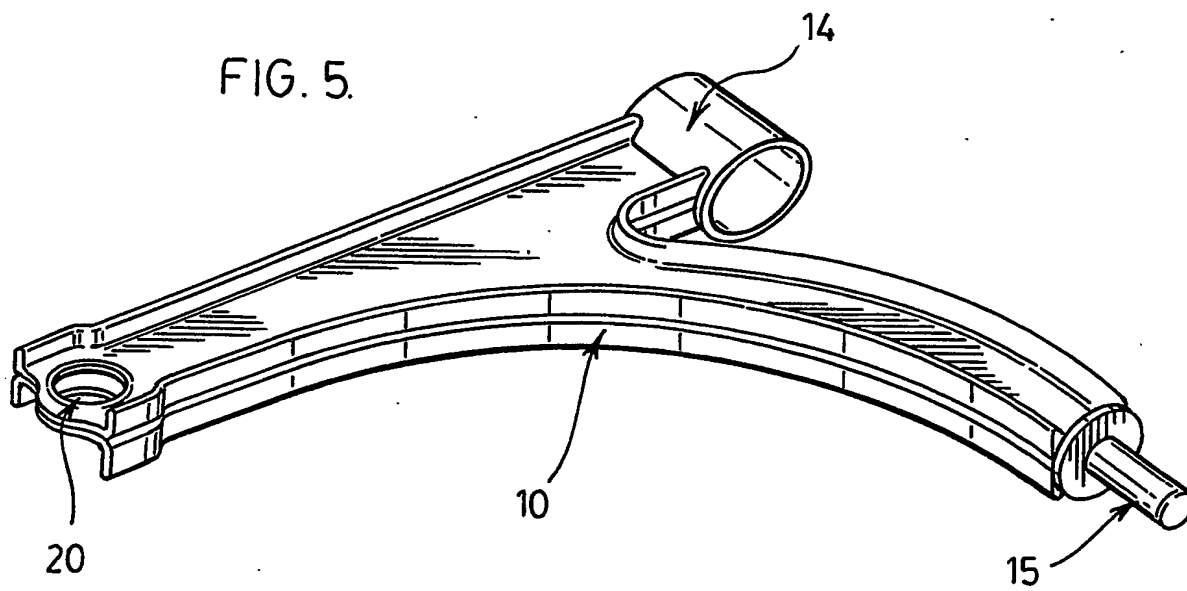


FIG. 5.



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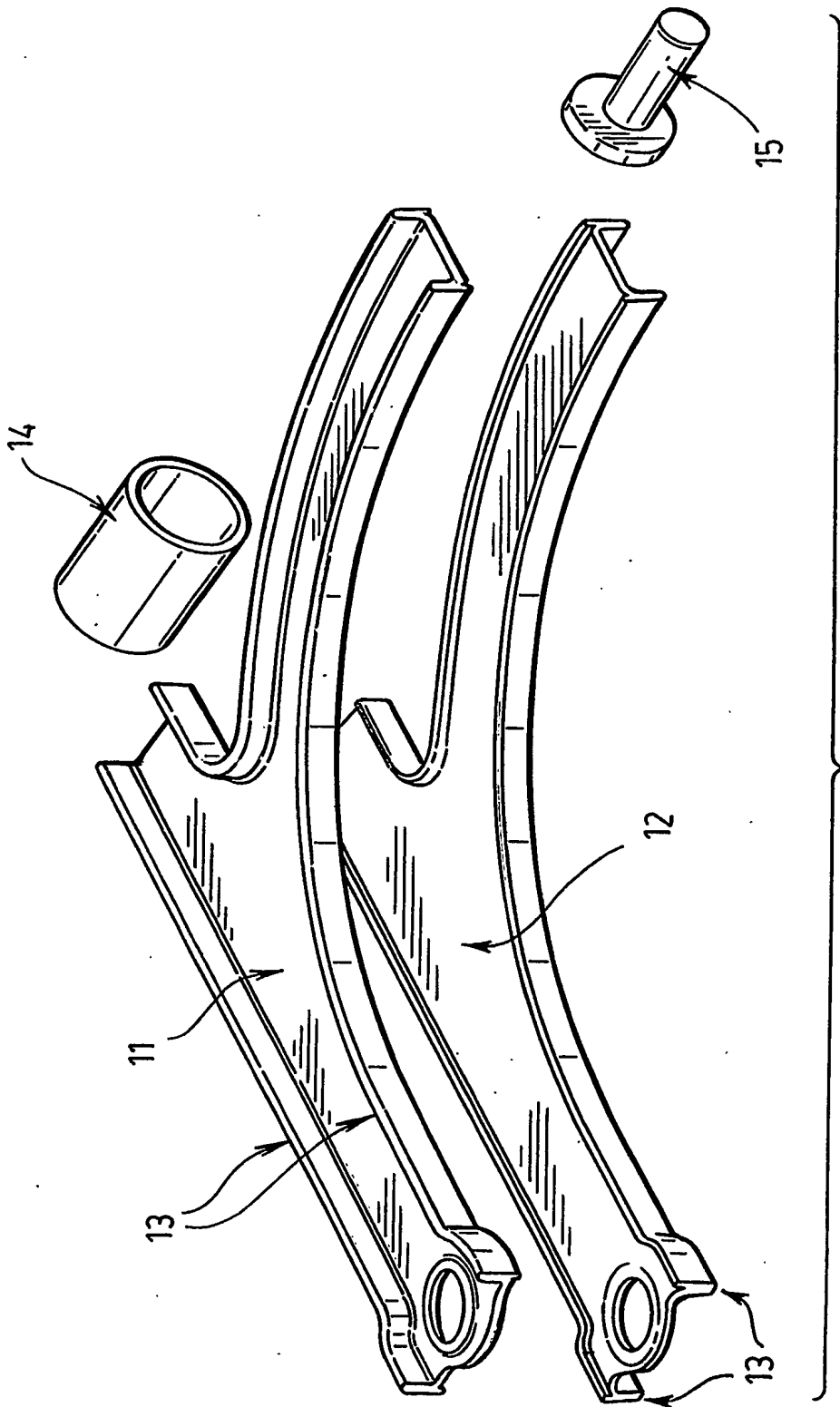


FIG. 6.

FIG. 7.

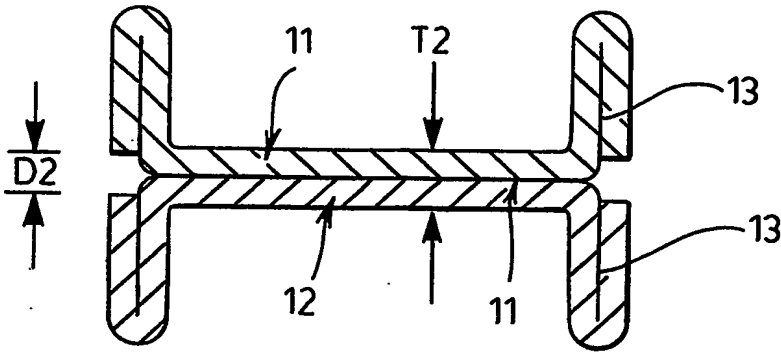


FIG. 7A.

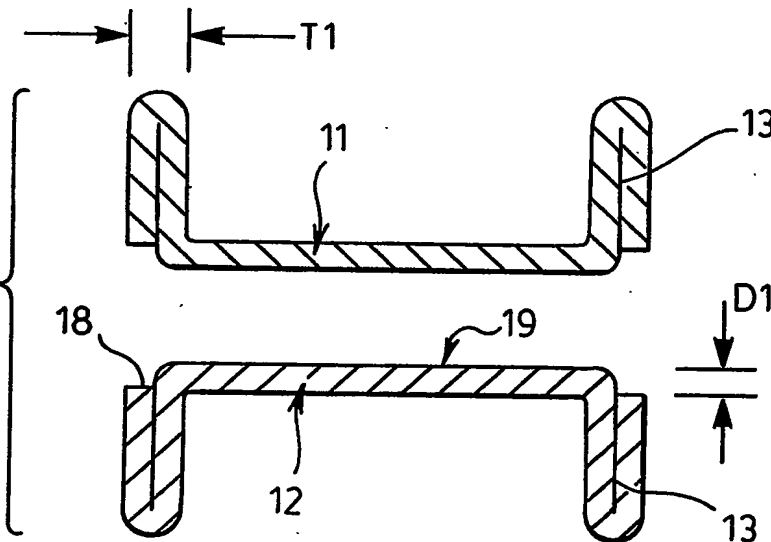
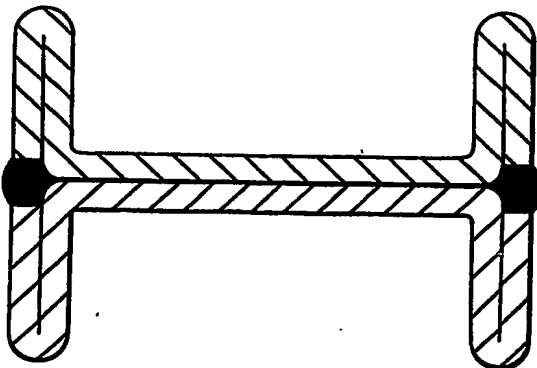


FIG. 8.



INTERNATIONAL SEARCH REPORT

International Application No
PCT/04/000055

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60G7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0 733 499 A (TOYOTA MOTOR CO LTD) 25 September 1996 (1996-09-25) cited in the application abstract; figures 9-17,20,21 ---	1-8
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 11, 29 November 1996 (1996-11-29) -& JP 08 188022 A (F TECH:KK), 23 July 1996 (1996-07-23) abstract; figures 1-3,6,8 ---	1-8
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 2004/000055

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